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LIGHT-EMITTING ELEMENT MODULE
[Hakkou soshi mojuuru]

Kunio Uehara

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INVENTOR	(72):	UEHARA, KUNIO
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Specification /405*

Title of the Invention

Light-Emitting Element Module

Claim

A light-emitting element module equipped with at least a light-emitting element and a lens installed in front of the emitting surface of the light-emitting element

characterized by part of the surface of the lens that faces the light-emitting element being provided with a flat or concave surface that has a reflecting film formed on it.

Detailed Description of the Invention

[Field of the Invention]

The present invention relates to a light-emitting element module.

[Related Art]

Conventionally, one or multiple lenses are utilized for the optical connection between a semiconductor light-emitting element and an optical fiber. For the lens that directly opposes the light-emitting element, in particular, a spherical lens consisting of a homogeneous material or a coaxial lens in which the refractive indexes of the material are distributed in the direction perpendicular to the axis is normally utilized.

[Problems that the Invention is to Solve]

A model drawing of a conventional light-emitting diode module is illustrated in Figure 3. In order to ensure a sufficient coupling

* Numbers in the margin indicate pagination in the foreign text.

efficiency, the incidence surface [131] of the spherical lens [13] is positioned away from the light emitting surface [231] of the light-emitting diode [23] by 100μm - 300μm. This structure is incapable of performing so-called APC (Automatic Power Control), by which part of the output light from the light-emitting diode is negatively fed back as a monitoring signal to keep the light output level constant.

Incidentally, a conventional Fabry-Perot semiconductor laser module has the structure illustrated in Fig. 4. In other words, light output from the emitting surface [241] on one side of the semiconductor laser [24] is connected to an optical fiber by means of an optical lens [14], and output light from the emitting surface [242] on the opposite side becomes converted into a current by means of a photodiode [44] and turns into the signal source of an APC circuit. However, when a distributed feedback semiconductor laser, which is one type of single axis mode /406
semiconductor lasers, is utilized in lieu of the above-described Fabry-Perot semiconductor laser (The advantages of a single axis mode semiconductor laser used as the optical source of optical fiber communication are common knowledge among those skilled in the art.), it creates the following problems.

In a conventional Fabry-Perot semiconductor laser, the injected-current dependencies of the output light from the light emitting surfaces are equivalent to each other during the fundamental transverse mode operation. In other words, if the output light from the side connected to the optical fiber is defined as P_o and the output light from the light emitting surface on the opposite side is defined as P_m, the P_m/P_o ratio

will be a constant value with respect to the injected current, I_p, and does not change. Therefore, in the model drawing of the optical fiber communication system illustrated in Figure 5, the ratio between the signal output, I_s, which is obtained by converting the current of the optical output at the transmission terminal, and the APC circuit signal source, I_m, is a constant value (the dotted line in Fig. 6) that does not depend on the current, I_p, injected to the semiconductor laser. However, in a distributed feedback semiconductor laser, one of the light outputs is suuboorina [as transliterated] with respect to the injected current, and the other light output is zaburina [as transliterated] with respect to the injected current in many cases. Therefore, the P_m/P_o ratio, which is to say the relationship between I_m and I_s, deviates from a straight line (the solid line in Fig. 6). This gap becomes manifested as a tracking error of the APC circuit when the mark rate of the transmission signal changes.

The invention is aimed at solving the above problems and at supplying a light-emitting element module capable of eliminating tracking errors in a distributed-feedback semiconductor laser, easily monitoring the output light in a light-emitting diode or the like, and performing APC.

[Means for Solving the Problem]

The light-emitting element module of the invention is equipped with a lens for optically connecting the light-emitting element and the optical fiber in front of the emitting surface of the light-emitting element, and part of the surface of the lens that faces the light-emitting element has a flat or concaved portion having the formation of a reflecting film.

According to the invention, part of the lens that faces the light-emitting element has a flat or concaved portion having the formation of a reflecting film, and part of the optical beam from the light-emitting element can be reflected and extracted in a direction away from the original emitting surface of the lens. Therefore, APC becomes possible with ease by receiving the optical beam reflected by the flat or concaved portion with the photodiode. Moreover, since part of the signal output beam is monitored in the distributed-feedback semiconductor laser, tracking errors caused by the difference between P_o/P_m and I_m/I_s can be eliminated.

[Embodiments of the Invention]

Next, the present invention will be described by referring to the accompanying drawings.

Figure 1 is a conceptual drawing of a semiconductor laser module in which a hemispherical-ended coaxial lens and illustrates one embodiment of the invention. Part of the convex incidence surface [111] of the hemispherical-ended coaxial lens [11] is provided with a plane portion [112], and its surface has a thin metal film deposited on it and demonstrates high reflectivity. Part of the optical beam [201] from the front incidence surface of the semiconductor laser [21] that became incident on the above-mentioned plane portion [112] becomes reflected here and then enters the photodiode [41]. The remaining components pass through the lens [11], exit from the emitting surface [113], pass through an optical isolator or other lenses if there are any in the later stages, and then enter the optical fiber [32]. The so-called coupling efficiency between the semiconductor laser [21] and optical fiber [32] is decided

by controlling the position and area of the plane portion [112] as well as the quantity of light made incident on the photodiode [41], and it was possible to keep the decrease of the coupling efficiency within 0.5dB while ensuring a sufficient light quantity for monitoring.

Figure 2 is a conceptual drawing of a light-emitting diode module in which a spherical lens is utilized and illustrates another embodiment of the invention. Part of the incidence-side spherical surface [121] of the spherical lens [12] is a concave spherical portion [122], and its surface has a metal film deposited on it and demonstrates high reflectivity. The components of the outgoing light [202] from the light-emitting diode [22] that became incident on the above-described concave portion [122] become reflected and enter the photodiode [42]. Since the reflecting surface provided to the lens is spherical in this embodiment, it is possible to converge the diffused light so that the light density on the photodiode's light-receiving surface will be higher than that of the case of a plane reflecting surface, and there are advantages in that it is possible to relax the accuracy of the photodiode's mounting position or to reduce the area of the photodiode's light receiving part.

[Effects of the Invention] /407

As explained in the above, according to the light-emitting element module of the invention, part of the incidence surface of the lens that faces the light-emitting element is a flat or concave portion having the formation of a reflecting film, and part of the irradiated optical beam is reflected in a direction away from the emitting surface. Thus, there is an effect in that the front light output of the semiconductor laser

and the light output of the light-emitting diode can be monitored by the light-receiving element, such as a photodiode. When the invention is applied to a distributed-feedback semiconductor laser or the like, tracking errors during an APC operation caused by the nonlinearity of I_s and I_m, such as that illustrated in Fig. 6, can be avoided by monitoring the front output light. When the invention is applied to a light-emitting diode, APC driving, which was conventionally impossible, becomes possible, and one can expect such effects as reducing the system margin with respect to the temporal fluctuations in the light output and also setting the initial driving current low in order to extend the element's tool life.

Figure 1 is a conceptual drawing of the semiconductor laser module of one embodiment of the invention. Figure 2 is a conceptual drawing of the light-emitting diode module of another embodiment of the invention. Figure 3 is a conceptual drawing of a conventional light-emitting diode module. Figure 4 is a conceptual drawing of a conventional semiconductor laser module. Figure 5 is a model drawing of a communication system in which a semiconductor laser is utilized. Figure 6 is a graph that indicates the ratio between the signal light intensity, I_s, and the monitoring light intensity, I_m.

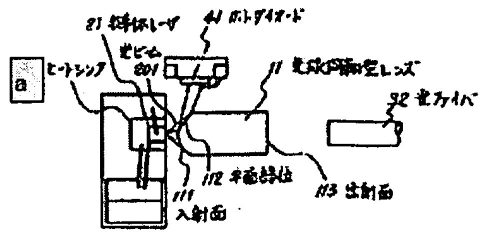

Figure 1
Key: 11) hemispherical-ended coaxial lens; 21) semiconductor laser; 32) optical fiber; 41) photodiode; 111) incidence surface; 112) plane portion; 113) emitting surface; 201) optical beam; a) heat sink.

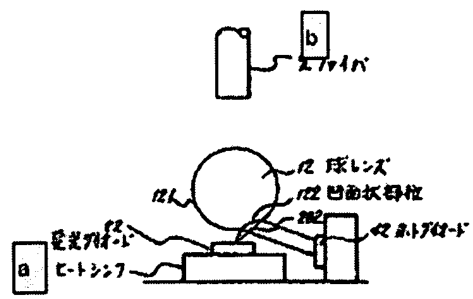

Figure 2
Key: 12)spherical lens; 22)light-emitting diode; 42)photodiode; 122)concave portion; a)heat sink; b)optical fiber.

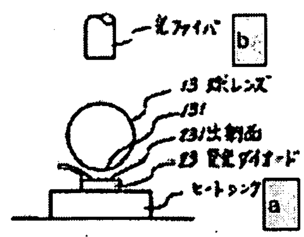

Figure 3
Key: 13) spherical lens; 23) light-emitting diode; 131) emitting surface; a) heat sink; b) optical fiber.

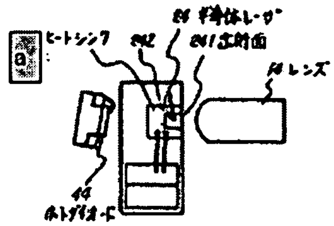

Figure 4
Key: 14)lens; 24)semiconductor laser; 44)photodiode; 241)emitting surface; a)heat sink.

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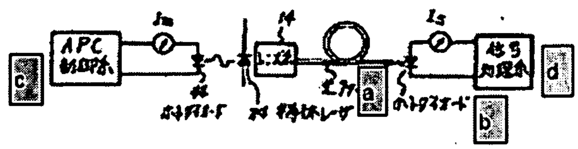

Figure 5
Key: 14)lens system; 24)semiconductor laser; 44)photodiode; a)optical fiber; b)photodiode; c)APC control system; d)signal processing system.

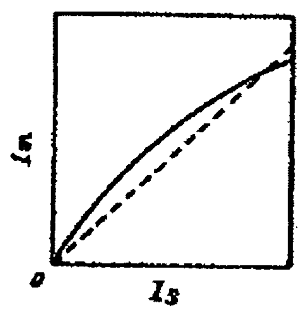

Figure 6